**Bond Enthalpy calculations**

***For additional information please use the values provided in the table below (referenced from previous NCEA Exam papers)***

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Bond** | **∆ *H* (kJ mol–1)** |  | **Bond** | **∆ *H* (kJ mol–1)** |
| H–H | 436 |  | C–H | 414 |
| C–C | 348 |  | N–H | 391 |
| C=C | 612 |  | O–H | 463 |
| https://github.com/JChemPaint/jchempaint/wiki/Jcp_tripleBond.png | 837 |  | Cl–H | 431 |
| H—Cl | 431 |  | C—O | 358 |
| N–N | 163 |  | C=O | 804 |
| N=N | 409 |  | C–N | 286 |
|  | 941 |  | C=N | 613 |
| O–O | 146 |  |  | 890 |
| O=O | 498 |  | C–Cl | 339 |
| Cl–Cl | 242 |  | Si–O | 374 |

**1)** Chlorine reacts with methane to form chloromethane and hydrogen chloride, as shown in the equation below.

CH4(*g*) + Cl2(*g*) → CH3Cl(*g*) + HCl(*g*)

Use the following bond enthalpies to calculate Δr *H*° for this reaction.

**2) a)** The equation for the combustion of propan-1-ol is:

CH3CH2CH2OH(*g*) + 4½O2(*g*) → 3CO2(*g*) + 4H2O(*g*) Δr*H* = –2010 kJ mol–1

Calculate the bond enthalpy for the C=O bond, using the enthalpy of the reaction above and the bond enthalpy data

**b)** Define bond enthalpy and explain why the bond enthalpy value calculated for C=O is higher than the C–O bond enthalpy.

**3)** Complete combustion of methanol can be represented by the following chemical equation: Use the bond enthalpies to calculate Δr*H* for this reaction.

2CH3OH(*g*) + 3O2(*g*) → 2CO2(*g*) + 4H2O(*g*)

**4)** The equation for the combustion of ethanol is: Calculate the bond enthalpy for the O–H bond

CH3CH2OH(*g*) + 3O2(*g*) → 2CO2(*g*) + 3H2O(*g*) Δr*H*° = –1379 kJ mol–1

**5)** Calculate the enthalpy change for the reaction below using the bond enthalpy data in the table.

CH3Cl(*g*) + NH3(*g*) → CH3NH2(*g*) + HCl(*g*)

#### 6) Methylhydrazine, N2H3CH3, can be used as a fuel. The structural formula for methylhydrazine is

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#### i) Define the term bond enthalpy.

#### ii) Use the bond enthalpies given in the table below to calculate the energy released when one mole of methylhydrazine vapour is burned.

#### N2H3CH3(g) + 2½O2(g) → CO2(g) + N2(g) + 3H2O(g)

#### 7) Calculate the enthalpy of formation of water in the gas state, ΔfH°(H2O, g)

#### 8) Carbon monoxide is reacted with steam to produce hydrogen gas.

#### CO(g) + H2O(g) 🡪 H2(g) + CO2(g) ΔrH = – 41.2 kJ mol–1

#### (i) The bond enthalpies for the carbon to oxygen bonds in CO2 and CO are different. Use the bond enthalpies and the enthalpy of the reaction to calculate the bond enthalpy of the carbon to oxygen bond in CO. Why are bond enthalpy values always positive? Explain the difference between the following bond enthalpies.

#### (ii) Why are bond enthalpy values always positive?

#### (iii) Explain the difference between the C – O and C = O enthalpies

#### 9) A fuel cell, such as that used on a space-craft, is similar to a battery. An example is the fuel cell that ‘burns’ hydrogen and oxygen to produce water and energy. The overall equation for the reaction is

#### 2H2(g) + O2(g) 🡪 2H2O(l ) ΔrH ° = – 572 kJ mol–1

#### a) If the water produced is in the gas phase the equation for the reaction is Use the bond enthalpies to calculate ΔrH ° for this reaction.

#### 2H2(g) + O2(g) 🡪 2H2O(g)

#### b) Write an equation for which the enthalpy change is equal to ΔvapH ° (H2O).

#### c) By considering the nature of the reaction in part (b), describe why it is an endothermic change. Using the information in parts above, calculate the value of ΔvapH ° (H2O).

**d)** Using the information in parts (a) to (c) above, calculate the value of Δvap*H °* (H2O).

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